

Overview

This standard covers the competence and knowledge technicians need to safely diagnose and rectify electrical, mechanical and fluid component faults in an electric vehicle powertrain and high voltage ancillary system, **NOT including the high voltage battery**, which is covered by a separate NOS (IMIEV10). The standard also ensures that the technician is aware of the effect that high voltage component technology has on other vehicle systems.

For the purposes of this standard, an electric vehicle is any vehicle that is in part or wholly electrically propelled. This would include

- Hybrid (HEV) - to include mild/micro hybrid vehicles where the voltage is considered dangerous.
- Plug-in Hybrid (PHEV)
- Extended Range Electric Vehicle (ER-EV) or Range Extended Electric Vehicle (RE-EV)
- Battery Electric Vehicle (BEV) or Pure Electric Vehicle (PEV)
- Fuel Cell Electric Vehicle (FCEV).

Warning: It has been recommended by industry experts that only those with suitable training and experience on working with electric vehicles should carry out the functions below. This may involve some diagnostic testing on the live system, appropriate to the level of competency.

**Performance
criteria**

- You must be able to:
- P1 Use suitable personal and vehicle protective equipment appropriate to the diagnosis and rectification activities carried out
 - P2 notify all relevant persons of your intention to work on a high voltage system
 - P3 Support the identification of **faults**, by reviewing vehicle:
 - P3.1 technical data
 - P3.2 diagnostic test procedures
 - P4 Prepare the vehicle systems and work area for safe working procedures as appropriate to the vehicle and the nature of the fault
 - P5 Prepare, check and use all the required **equipment** following manufacturer's instructions
 - P6 Use **diagnostic methods** which are relevant to the symptoms presented
 - P7 Collect sufficient diagnostic information in a logical and systematic way to enable an accurate diagnosis of the high voltage system **faults**
 - P8 Identify and record any system deviation from manufacturer's specifications accurately
 - P9 Ensure your assessment of components and units identifies their condition and suitability for repair or replacement
 - P10 Promptly inform the relevant person(s) where repairs are uneconomic or unsatisfactory to the customer
 - P11 Carry out all diagnostic and rectification activities following:
 - P11.1 manufacturer's instructions
 - P11.2 recognised repair methods
 - P11.3 your workplace procedures
 - P11.4 health, safety and environmental requirements
 - P12 Work in a way which minimises the risk of:
 - P12.1 **damage** to other vehicle systems
 - P12.2 **damage** to other components and units
 - P12.3 injury to self and others
 - P13 Ensure all repaired and replacement components and units conform to the vehicle operating specification and any legal requirements
 - P14 Adjust components and units, when necessary, correctly to ensure that they

- operate to system requirements
- P15 Promptly record and report any additional **faults** you notice during the course of work
 - P16 Use testing methods which are suitable for assessing the performance of the rectified system
 - P17 Ensure the rectified system performs to the vehicle operating specification and any legal requirements prior to return to the customer
 - P18 Follow workplace procedures in case of emergency
 - P19 Ensure your records are accurate, complete and passed to the relevant person(s) within the agreed timescale and in the format required
 - P20 Complete all activities within the agreed timescale
 - P21 Promptly report any anticipated delays in completion to the relevant person(s)

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Knowledge and understanding

You need to know and understand:

Use of technical information

- K1 The different types of electric vehicle
- K2 How to find, interpret and use sources of information on high and low voltage electrical and electronic, mechanical and fluid system operating specifications, diagnostic test procedures, repair procedures and legal requirements
- K3 Vehicle operating specifications relating to high and low voltage electrical, electronic, mechanical and fluid systems for the vehicle(s) on which you work
- K4 The importance of using the correct sources of technical information for electric vehicle system diagnosis and rectification

Legislative and organisational requirements and procedures

- K5 the legislation, industry codes of practice or guidelines and workplace procedures relevant to:
 - K5.1 health and safety
 - K5.2 the environment (including waste disposal)
 - K5.3 appropriate personal and vehicle protective equipment
 - K5.4 legal requirements relating to the vehicle (including road safety requirements)
- K6 Your workplace procedures for:
 - K6.1 recording fault location and correction activities
 - K6.2 reporting the results of tests
 - K6.3 the referral of problems
 - K6.4 reporting delays to the completion of work
- K7 How to confirm an electric vehicle is safe to work on and the precautions you should take to ensure the high voltage system cannot be re-energised without your knowledge and agreement
- K8 The hazards associated with electric vehicle high voltage systems and batteries
- K9 How to reduce the risk of high voltage hazards when working on and around electric vehicles
- K10 The implications and effects of electricity through the human body
- K11 The signs and symptoms of electrocution
- K12 The implications of strong magnetic fields and the effects on medical devices

- K13 Workplace procedures that must be followed in the event of electric shock and other emergencies
- K14 The hazards associated with electric vehicles when exposed to extreme temperatures, impact and other adverse conditions
- K15 How to store, dispose of, recycle and return any removed high voltage components in line with legislative and organisational requirements
- K16 How to work safely avoiding **damage** to other vehicle systems, components and units and contact with leakage and hazardous substances
- K17 The hazards associated with **a** and systems, including alternative fuels and hydrogen fuel cells
- K18 The importance of working to agreed timescales and keeping others informed of progress
- K19 The relationship between time, costs and productivity
- K20 The importance of promptly reporting anticipated delays to the relevant person(s)

High and low voltage component faults, their diagnosis and rectification

- K21 How high and low voltage electrical, electronic, mechanical and fluid systems are constructed and operate
- K22 How high and low voltage electrical, electronic, mechanical and fluid systems are dismantled, reassembled and adjusted to manufacturer's specifications
- K23 The types and causes of high and low voltage electrical, electronic, mechanical and fluid system, component and unit **faults** and failures
- K24 High and low voltage electrical, electronic, mechanical and fluid component unit and replacement procedures, the circumstances which will necessitate replacement and other possible courses of action
- K25 The importance of working to recognised diagnostic and rectification procedures and processes and obtaining the correct information for diagnostic and rectification activities to proceed
- K26 The importance of recording diagnostic and rectification information
- K27 How to select the most appropriate **diagnostic testing** method for the symptoms presented
- K28 How to carry out systematic **diagnostic testing** of high and low voltage electrical, electronic, mechanical and fluid systems using prescribed processes

or formats

- K29 How to assess the condition of high and low voltage electrical, electronic, mechanical and fluid components and units
- K30 How to interpret test results and vehicle data in order to identify the location and cause of high and low voltage system **faults**
- K31 How to carry out the rectification activities in order to correct **faults** in the high and low voltage electrical, electronic, mechanical and fluid systems
- K32 The relationship between test methodology and the **faults** repaired – the use of appropriate testing methods
- K33 How to make cost effective recommendations for rectification
- K34 The components of all fuel sources and systems on electric vehicles, including hydrogen fuel cells

Electrical and electronic principles

- K35 Electrical and electronic principles, including ohms law, voltage, power, current (ac/dc), resistance, magnetism, electromagnetism and electromagnetic induction
- K36 Electrical symbols, unit and terms
- K37 Electrical and electronic principles associated with high voltage systems, including types of sensors and actuators, their application and operation
- K38 The operating principles of electric vehicle components
- K39 How electrical and electronic high and low voltage systems operate, including electrical component function, electrical inputs, outputs, voltages and oscilloscope patterns, digital and fibre optics principles
- K40 How electrical and electronic systems interlink and interact, including multiplexing
- K41 The interaction between electrical, electronic, magnetic, chemical and mechanical components within electric vehicle systems
- K42 The principles of chassis and insulated return systems as appropriate to electric vehicles
- K43 Specific high voltage circuit protection

Use of diagnostic and rectification equipment

- K44 How to prepare and check the accuracy of **diagnostic testing equipment**

K45 How to use diagnostic and rectification **equipment** for high and low voltage electrical, mechanical, electronic, and fluid systems, specialist repair tools and general workshop equipment

Vehicle system operation

- K46 The main differences between an electric vehicle and a non-electric vehicle and its basic operation, including regeneration
- K47 How to safely operate an electric vehicle
- K48 The specific manufacturer's guidelines and the precautions necessary when charging, connecting an auxiliary power source to or towing/lifting an electric vehicle
- K49 How to mobilise an electric vehicle safely
- K50 The charging systems (types and modes) associated with electric vehicles and how to charge electric vehicles safely
- K51 The implications of remote vehicle control

Scope/range

1. **Faults** occur within:
 - 1.1. High voltage electrical system and components (including high voltage ancillary units and components and batteries)
 - 1.2. Low voltage electrical and electronic systems and components (including motor generator/charging systems)
 - 1.3. Onboard plug-in charging systems
 - 1.4. Mechanical components
 - 1.5. Fluid systems

2. **Diagnostic methods** are:
 - 2.1. sensory
 - 2.2. measurement
 - 2.3. functional testing

3. **Diagnostic Testing** is defined as:
 - 3.1. Identify the fault
 - 3.2. Verify the fault
 - 3.3. Collect further information
 - 3.4. Evaluate the evidence
 - 3.5. Carry out further tests in a logical sequence
 - 3.6. Rectify the problem
 - 3.7. Check all systems

4. **Equipment** is:
 - 4.1. diagnostic and rectification equipment for high voltage systems
 - 4.2. diagnostic and rectification equipment for low voltage systems
 - 4.3. diagnostic and rectification equipment for mechanical systems
 - 4.4. diagnostic and rectification equipment for fluid systems
 - 4.5. specialist repair tools
 - 4.6. general workshop equipment

5. **High voltage personal protective equipment** includes but is not limited to:
 - 5.1. insulated high voltage gloves
 - 5.2. face shield
 - 5.3. electrical/fire resistant clothing/apron
 - 5.4. insulated tools
 - 5.5. rubber mat

6. **Damage** to high voltage components includes but is not limited to:
 - 6.1. overheating
 - 6.2. physical impact damage
 - 6.3. chemical leakage
 - 6.4. smoke
 - 6.5. water damage
 - 6.6. different battery chemistries
 - 6.7. reduction in energy holding capacity
 - 6.8. overcharging due to internal electrical damage

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**Additional
Information****Glossary**

This section contains examples and explanations of some of the terms used but does not form part of the standard.

Hazards associated with high voltage electrical vehicle components - exist not only during work on high voltage systems, as specified above, but also on all other high-power electrical drive systems and high-pressure storage systems. Vehicle and equipment manufacturers' guidance should be followed at all times.

High voltage – Regulation No 100 of the Economic Commission for Europe of the United Nations (UNECE) — Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train, states that: 'High Voltage' means the classification of an electric component or circuit, if its working voltage is $> 60 \text{ V}$ and $\leq 1\,500 \text{ V DC}$ or $> 30 \text{ V}$ and $\leq 1\,000 \text{ V AC}$ root mean square (rms). Electricity at Work Regulations (1989), and associated HSE guidance should be followed at all times.

N.B. Some electric vehicles may operate at voltages below or above industry recognised standards.

Sensory testing methods - include looking, listening, smelling, touching for temperature or vibration.

Sources of information applicable to electric vehicles - examples include hard copy manuals, data on computer and data obtained from on-board diagnostic displays.

Vehicle - any vehicle that is in part or wholly electrically propelled. This would include

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1.5. Fuel Cell Electric Vehicle (FCEV)

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Originating organisation	IMI Ltd
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Relevant occupations	Heavy Vehicle Trailer Service Technician (Automotive); Heavy Vehicle Trailer Diagnostic Technician (Automotive); Heavy Vehicle Trailer Master Technician (Automotive); Heavy Vehicle Trailer Fleet/Service Manager (Automotive); Heavy Vehicle Service Technician (Automotive); Heavy Vehicle Diagnostic Technician (Automotive); Heavy Vehicle Master Technician (Automotive); Heavy Vehicle Fleet/Service Manager (Automotive); Light Vehicle Service Technician (Automotive); Light Vehicle Diagnostic Technician (Automotive); Light Vehicle Master Technician (Automotive); Light Vehicle Fleet/Service Manager (Automotive); Mechanical, Electrical and Trim Assistant Technician (Automotive); Mechanical, Electrical and Trim Technician (Automotive); Motorcycle Service Technician (Automotive); Motorcycle Diagnostic Technician (Automotive); Motorcycle Master Technician (Automotive); Motorcycle Fleet/Service Manager (Automotive); Lift Truck Service Technician (Automotive); Lift Truck Trailer Diagnostic

Technician (Automotive); Lift Truck Trailer Master Technician (Automotive); Lift Truck Workshop Controller (Automotive); Auto-electrical Technician (Automotive); Automotive Aftermarket Electrical Enhancement Technician (Automotive); Workshop Supervisor (Automotive); Bus and Coach Mechanic; Bus and Coach Electrician; Bus and Coach Mechelec; Bus and Coach Master Technician

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Electric and Hybrid Vehicles;

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Electric Vehicle; diagnosis; rectification; electrical components; high voltage.

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